**CLAIMS:**

1. A method of making a highly crystalline cross-linked polymeric material comprising:

a) heating a polymeric material to a temperature above the melt;

b) pressurizing the heated polymeric material under at least about 10-1000 MPa;

c) holding the polymeric material at this pressure;

d) cooling the heated polymeric material to about room temperature;

e) releasing the pressure to an atmospheric pressure level, thereby forming a highly crystalline polymeric material; and

f) irradiating the highly crystalline polymeric material at temperature below the melt with ionizing radiation, thereby forming a highly crystalline cross-linked polymeric material.

2. A method of making a highly crystalline cross-linked polymeric material comprising:

a) pressurizing a polymeric material under at least about 10-1000 MPa;

b) heating the pressurized polymeric material to a temperature below the melt of the pressurized polymeric material;

c) holding at this pressure and temperature;

d) cooling the heated polymeric material to about room temperature;

e) releasing the pressure to an atmospheric pressure level, thereby forming a highly crystalline polymeric material; and

f) irradiating the highly crystalline polymeric material at temperature below the melt with ionizing radiation, thereby forming a highly crystalline cross-linked polymeric material.

3. The method of claim 1, wherein the pressurized polymeric material is heated to a temperature about 180°C or about 225°C.

4. The method of claim 2, wherein the pressurized polymeric material is heated to a temperature below 150°C.

5. The method of claim 1 or 2, wherein the highly crystalline polymeric material is irradiated at a temperature between about room temperature and about 90°C.

6. The method of claim 1 or 2, wherein the highly crystalline polymeric material is irradiated at a temperature between about 90°C and the peak melting point of the highly crystalline polymeric material.

7. The method of claim 1 or 2, wherein the polymeric material is pressurized to about 320 MPa.

8. The method of claim 1 or 2 further comprising doping the highly crystalline cross-linked polymeric material with an antioxidant by diffusion, thereby forming an antioxidant-doped highly crystalline cross-linked polymeric material.

9. A method of claim 1 further comprising:

a) heating a polymeric material to a temperature above the melt;

b) pressurizing the heated polymeric material under at least about 10-1000 MPa;

c) holding the polymeric material at this pressure;

d) cooling the heated polymeric material to about room temperature;

e) releasing the pressure to an atmospheric pressure level, thereby forming a highly crystalline polymeric material cross-linked polymeric material.

10. A method of claim 2 further comprising:

a) heating a polymeric material to a temperature below the melt;

b) pressurizing the heated polymeric material under at least about 10-1000 MPa;

c) holding the polymeric material at this pressure;

d) cooling the heated polymeric material to about room temperature;

e) releasing the pressure to an atmospheric pressure level, thereby forming a highly crystalline polymeric material cross-linked polymeric material.

11. The method of claim 1, 2, 9, or 10 further comprising:

a) doping the highly crystalline cross-linked polymeric material with an antioxidant, thereby forming an antioxidant-doped highly crystalline cross-linked polymeric material;

b) mechanically deforming the polymeric material below its melting point; and

c) annealing the mechanically deformed polymeric material at a temperature below the melting point, thereby forming an antioxidant-doped highly crystalline cross-linked polymeric material containing substantially no detectable residual free radicals.

12. The method of claim 1 or 2 further comprising:

a) machining the highly crystalline cross-linked polymeric material, thereby forming a medical implant; and

b) doping the medical implant with an antioxidant by diffusion, thereby forming an antioxidant-doped highly crystalline cross-linked medical implant.

13. The method of claim 1 or 2 further comprising:

a) doping the highly crystalline cross-linked polymeric material with an antioxidant by diffusion, thereby forming an antioxidant-doped highly crystalline cross-linked polymeric material; and

b) machining the antioxidant-doped highly crystalline cross-linked polymeric material, thereby forming an antioxidant-doped highly crystalline cross-linked medical implant.

14. The method of claim 11, 12, or 13, wherein the antioxidant-doped highly crystalline cross-linked medical implant is packaged and sterilized by ionizing radiation or gas sterilization, thereby forming a sterile and antioxidant-doped highly crystalline cross-linked medical implant.

15. The method of making oxidation-resistant highly crystalline, cross-linked polymeric material comprising:

a) heating a polymeric material at temperature above the melt;

b) pressurizing the highly crystalline cross-linked polymeric material under at least about 10-1000 MPa;

c) holding at this pressure;

d) cooling the heated polymeric material to room temperature;

e) releasing the pressure to an atmospheric pressure level;

f) doping the polymeric material with an antioxidant by diffusion, thereby forming an antioxidant-doped polymeric material; and

g) irradiating the antioxidant-doped polymeric material at temperature below the melt with ionizing radiation, thereby forming an antioxidant-doped highly crystalline cross-linked polymeric material.

16. The method of making oxidation-resistant highly crystalline, cross-linked polymeric material comprising:

a) pressurizing a polymeric material under at least above 10-1000 MPa;

b) heating the pressurized polymeric material at temperature below the melt of the pressurized polymeric material;

c) holding at this pressure and temperature;

d) cooling the heated polymeric material to room temperature;

d) releasing the pressure to an atmospheric pressure level;

e) doping the highly crystalline polymeric material with an antioxidant by diffusion, thereby forming an antioxidant-doped highly crystalline polymeric material; and

f) irradiating the antioxidant-doped polymeric material at temperature below the melt with ionizing radiation, thereby forming an antioxidant-doped highly crystalline cross-linked polymeric material.

17. The method of claim 15 or 16, wherein the antioxidant-doped highly crystalline cross-linked polymeric material is machined thereby forming a medical implant, this medical

implant is packaged and sterilized by ionizing radiation or gas sterilization, thereby forming a sterile and antioxidant-doped highly crystalline cross-linked medical implant.

18. The method of claim 15 or 16, wherein the antioxidant-doped highly crystalline cross-linked polymeric material is machined thereby forming a medical implant, this medical implant is packaged and sterilized by ionizing radiation or gas sterilization, thereby forming a sterile and antioxidant-doped highly crystalline cross-linked medical implant.

19. A method of making a antioxidant-doped highly crystalline polymeric material comprising:

a) heating a polymeric material at temperature above the melt;

b) pressurizing the highly crystalline cross-linked polymeric material under at least about 10-1000 MPa;

c) holding at this pressure;

d) cooling the heated polymeric material to room temperature;

e) releasing the pressure to an atmospheric pressure level;

f) machining thereby forming a medical implant;

g) doping the medical implant with an antioxidant by diffusion, thereby forming an antioxidant-doped medical implant; and

g) irradiating the antioxidant-doped medical implant at temperature below the melt with ionizing radiation, thereby forming an antioxidant-doped highly crystalline cross-linked medical implant.

20. The method of making oxidation-resistant highly crystalline, cross-linked polymeric material comprising:

a) pressurizing a polymeric material under at least above 10-1000 MPa;

b) heating the pressurized polymeric material at temperature below the melt of the pressurized polymeric material;

c) holding at this pressure and temperature;

d) cooling the heated polymeric material to room temperature;

e) releasing the pressure to an atmospheric pressure level;

f) machining thereby forming a medical implant;

g) doping the medical implant with an antioxidant by diffusion, thereby forming an antioxidant-doped medical implant; and

h) irradiating the antioxidant-doped medical implant at temperature below the melt with ionizing radiation, thereby forming an antioxidant-doped highly crystalline cross-linked medical implant.

21. The method of claim 19 or 20, wherein the antioxidant-doped highly crystalline cross-linked medical implant is packaged and sterilized by ionizing radiation or gas sterilization, thereby forming a sterile and antioxidant-doped highly crystalline cross-linked medical implant.

22. A method of claim 1 or 2, wherein the polymeric material is a blend of polymer and an additive.

23. The method of claim 22, wherein the highly crystalline cross-linked polymeric material is machined thereby forming a medical implant, this medical implant is packaged and sterilized by ionizing radiation or gas sterilization, thereby forming a sterile and antioxidant-doped highly crystalline cross-linked medical implant.

24. A medical implant comprising the highly crystalline cross-linked polymeric material according to claim 1, 2, 9, 10, 11, 15, or 16.

25. A medical implant comprising the antioxidant-doped highly crystalline cross-linked polymeric material according to claim 19 or 20.

26. The method of claim 12 or 13, wherein the polymeric material is compression molded to another piece or a medical implant, thereby forming an interface or an interlocked hybrid material.

27. The method of claim 11, 12, 13, 15, 16, 19, or 20, wherein the doping is carried out by soaking the medical implant in the antioxidant for about an hour or about 16 hours.

28. The method of claim 1, 2, 9, 10, 12, 13, 15, 16, 19, or 20 further comprising:

a) mechanically deforming the polymeric material below its melting point; and

b) annealing the mechanically deformed polymeric material at a temperature below the melting point, thereby forming an antioxidant-doped highly crystalline cross-linked polymeric material containing substantially no detectable residual free radicals.

29. The method of claim 1, 2, 15, 16, 19, or 20, wherein the polymeric material is a polyolefin, a polypropylene, a polyamide, a polyether ketone, or a mixture thereof.

30. The polyolefin of claim 29 is selected from a group consisting of a low-density polyethylene, high-density polyethylene, linear low-density polyethylene, ultra-high molecular weight polyethylene (UHMWPE), or a mixture thereof.

31. The method according to claim 19 or 20, wherein the implant comprises medical devices selected from the group consisting of acetabular liner, shoulder glenoid, patellar component, finger joint component, ankle joint component, elbow joint component, wrist joint component, toe joint component, bipolar hip replacements, tibial knee insert, tibial knee inserts with reinforcing metallic and polyethylene posts, intervertebral discs, sutures, tendons, heart valves, stents, vascular grafts.

32. The method according to claim 1, 2, 15, 16, 19, or 20, wherein the polymeric material is polymeric resin powder, polymeric flakes, polymeric particles, or the like, or a mixture thereof or an additive.

33. The method according to claim 1, 2, 15, 16, 19, or 20, wherein the irradiation is carried out in an atmosphere containing between about 1% and about 22% oxygen.

34. The method according to claim 1, 2, 15, 16, 19, or 20, wherein the irradiation is carried out in an inert atmosphere, wherein the inert atmosphere contains gas selected from the group consisting of nitrogen, argon, helium, neon, or the like, or a combination thereof.

35. The method according to claim 1, 2, 15, 16, 19, or 20, wherein the irradiation is carried out in a vacuum.

36. The method according to claim 1, 2, 15, 16, 19, or 20, wherein the radiation dose is between about 25 and about 1000 kGy.

37. The method according to claim 1, 2, 15, 16, 19, or 20, wherein the radiation dose is about 65 kGy, about 75kGy, or about 150 kGy.

38. The method according to claim 1, 2, 15, 16, 19, or 20, wherein the radiation is a gamma irradiation.

39. The method according to claim 1, 2, 15, 16, 19, or 20, wherein the radiation is an electron beam irradiation.

40. A method of making oxidation-resistant cross-linked highly crystalline blend of polymeric material and additive comprising:

a) blending the polymeric material with an additive;

b) consolidating the blend;

c) heating the polymeric material to a temperature above the melt;

d) pressurizing the polymeric material under at least about 10-1000 MPa;

e) holding at this pressure and temperature;

f) cooling the heated polymeric material to about room temperature;

g) releasing the pressure to about an atmospheric pressure level, thereby forming a highly crystalline polymeric material;

h) irradiating the polymeric material at a temperature below the melt with ionizing radiation, thereby forming a highly crystalline cross-linked polymeric material;

i) heating the highly crystalline highly cross-linked blend to above the melt;

j) pressuring the highly cross-linked blend under at least about 10-1000 MPa;

k) holding at this pressure and temperature;

l) cooling the heated blend to about room temperature; and

m) releasing the pressure to about an atmospheric pressure level, thereby forming oxidation-resistant highly crystalline highly cross-linked blend of polymeric material and additive.

41. A method of making oxidation-resistant cross-linked highly crystalline blend of polymeric material and additive comprising:

a) blending the polymeric material with an additive;

b) consolidating the blend;

c) heating the polymeric material to a temperature above the melt;

d) pressurizing the polymeric material under at least about 10-1000 MPa;

e) holding at this pressure and temperature;

f) cooling the heated polymeric material to about room temperature;

g) releasing the pressure to about an atmospheric pressure level, thereby forming a highly crystalline polymeric material;

h) irradiating the polymeric material at a temperature below the melt with ionizing radiation, thereby forming a highly crystalline cross-linked polymeric material;

i) pressuring the highly crystalline highly cross-linked polymeric material under at least 10-1000 MPa;

j) heating the pressurized polymeric material to a temperature of above 100°C to below the melt of the pressurized highly crystalline highly cross-linked polymeric material;

k) holding at this pressure and temperature;

l) cooling the heated polymeric material to about room temperature; and

m) releasing the pressure to about an atmospheric pressure level, thereby forming a highly crystalline highly cross-linked blend of polymeric material and additive.

42. A method of making oxidation-resistant highly cross-linked highly crystalline blend of polymeric material and additive comprising:

a) pressuring the polymeric material under at least about 10-1000 MPa;

b) heating the pressurized polymeric material to a temperature of above 100°C to below the melt of the pressurized polymeric material;

c) holding at this pressure and temperature;

d) cooling the heated polymeric material to about room temperature;

e) releasing the pressure to about an atmospheric pressure level, thereby forming a highly crystalline blend;

f) irradiating the blend at a temperature below the melt with ionizing radiation, thereby forming a highly crystalline cross-linked blend;

g) heating the highly crystalline highly cross-linked blend to a temperature above the melt; h) pressurizing the highly cross-linked blend under at least about 10-1000 MPa;

i) holding at this pressure and temperature;

j) cooling the heated highly cross-linked blend to about room temperature; and

k) releasing the pressure to about an atmospheric pressure level, thereby forming oxidation-resistant highly crystalline highly cross-linked blend of polymeric material and additive.

43. A method of making oxidation-resistant highly cross-linked highly crystalline blend of polymeric material and additive comprising:

a) pressuring the polymeric material under at least about 10-1000 MPa;

b) heating the pressurized polymeric material to a temperature of above 100°C to below the melt of the pressurized polymeric material;

c) holding at this pressure and temperature;

d) cooling the heated polymeric material to about room temperature;

e) releasing the pressure to about an atmospheric pressure level, thereby forming a highly crystalline blend;

f) irradiating the blend at a temperature below the melt with ionizing radiation, thereby forming a highly crystalline cross-linked blend;

g) pressuring the highly crystalline, highly cross-linked blend under at least about 10-1000 MPa;

h) heating the pressurized cross-linked blend under at least about 10-1000 MPa;

i) heating the pressurized cross-linked blend to a temperature of above 100°C to below the melt of the pressurized highly crystalline, highly cross-linked blend;

j) holding at this pressure and temperature;

k) cooling the heated cross-linked blend to about room temperature; and

l) releasing the pressure to about an atmospheric pressure level, thereby forming oxidation-resistant highly crystalline highly cross-linked blend of polymeric material and additive.

44. A method of making oxidation-resistant cross-linked highly crystalline blend of polymeric material and additive comprising:

a) blending the polymeric material with an additive;

b) consolidating the blend;

c) heating the blend to a temperature above the melt;

d) pressurizing the blend under at least 10-1000 MPa;

e) holding at this pressure and temperature;

f) cooling the heated blend to about room temperature;

g) releasing the pressure to about an atmospheric pressure level, thereby forming a highly crystalline blend;

h) irradiating the blend at a temperature below the melt with ionizing radiation, thereby forming a highly crystalline cross-linked blend;

i) mechanically deforming the highly crystalline highly cross-linked blend below its melting point; and

j) annealing the mechanically deformed highly crystalline highly crosslinked blend at a temperature below the melting point, thereby forming oxidation-resistant highly crystalline highly cross-linked blend of polymeric material and additive.

45. A method of making oxidation-resistant cross-linked highly crystalline blend of polymeric material and additive comprising:

a) blending the polymeric material with an additive;

b) consolidating the blend;

c) pressuring the blend under at least 10-1000 MPa;

d) heating the pressurized blend to a temperature of above 100°C to below the melt of the pressurized blend;

e) holding at this pressure and temperature;

f) cooling the heated blend to about room temperature;

g) releasing the pressure to about an atmospheric pressure level, thereby forming a highly crystalline blend;

h) irradiating the blend at a temperature below the melt with ionizing radiation, thereby forming a highly crystalline cross-linked blend;

i) mechanically deforming the highly crystalline highly cross-linked blend below its melting point; and

j) annealing the mechanically deformed highly crystalline highly crosslinked blend at a temperature below the melting point, thereby forming oxidation-resistant highly crystalline highly cross-linked blend of polymeric material and additive.

46. A method of making oxidation-resistant cross-linked highly crystalline blend of polymeric material and additive comprising:

a) blending the polymeric material with an additive;

b) consolidating the blend;

c) heating the polymeric material to a temperature above the melt;

d) pressurizing the polymeric material under at least 10-1000 MPa;

e) holding at this pressure and temperature;

f) cooling the heated polymeric material to about room temperature;

g) releasing the pressure to about an atmospheric pressure level, thereby forming a highly crystalline polymeric material;

h) irradiating the polymeric material at a temperature below the melt with ionizing radiation, thereby forming a highly crystalline cross-linked polymeric material;

i) heating the highly crystalline highly cross-linked blend to above the melt;

j)pressuring the highly cross-linked blend under at least 10-1000 MPa;

k) holding at this pressure and temperature;

l) cooling the heated blend to about room temperature; and

m) releasing the pressure to about an atmospheric pressure level, thereby forming oxidation-resistant highly crystalline highly cross-linked blend of polymeric material and additive.

47. A method of making oxidation-resistant cross-linked highly crystalline blend of polymeric material and additive comprising:

a) blending the polymeric material with an additive;

b) consolidating the blend;

c) heating the polymeric material to a temperature above the melt;

d) pressurizing the polymeric material under at least 10-1000 MPa;

e) holding at this pressure and temperature;

f) cooling the heated polymeric material to about room temperature;

g) releasing the pressure to about an atmospheric pressure level, thereby forming a highly crystalline polymeric material;

h) irradiating the polymeric material at a temperature below the melt with ionizing radiation, thereby forming a highly crystalline cross-linked polymeric material;

i) pressuring the highly crystalline highly cross-linked polymeric material under at least 10-1000 MPa;

j) heating the pressurized polymeric material to a temperature of above 100°C to below the melt of the pressurized highly crystalline highly cross-linked polymeric material;

k) holding at this pressure and temperature;

l) cooling the heated polymeric material to about room temperature; and

m) releasing the pressure to about an atmospheric pressure level, thereby forming a highly crystalline highly cross-linked blend of polymeric material and additive.

48. A method of making oxidation-resistant highly cross-linked highly crystalline blend of polymeric material and additive comprising:

a) pressuring the polymeric material under at least 10-1000 MPa;

b) heating the pressurized polymeric material to a temperature of above 100°C to below the melt of the pressurized polymeric material;

c) holding at this pressure and temperature;

d) cooling the heated polymeric material to about room temperature;

e) releasing the pressure to about an atmospheric pressure level, thereby forming a highly crystalline blend;

f) irradiating the blend at a temperature below the melt with ionizing radiation, thereby forming a highly crystalline cross-linked blend;

g) heating the highly crystalline highly cross-linked blend to a temperature above the melt;

h) pressurizing the highly cross-linked blend under at least 10-1000 MPa;

i) holding at this pressure and temperature;

j) cooling the heated highly cross-linked blend to about room temperature; and

k) releasing the pressure to about an atmospheric pressure level, thereby forming oxidation-resistant highly crystalline highly cross-linked blend of polymeric material and additive.

49. A method of making oxidation-resistant highly cross-linked highly crystalline blend of polymeric material and additive comprising:

a) pressuring the polymeric material under at least 10-1000 MPa;

b) heating the pressurized polymeric material to a temperature of above 100°C to below the melt of the pressurized polymeric material;

c) holding at this pressure and temperature;

d) cooling the heated polymeric material to about room temperature;

e) releasing the pressure to about an atmospheric pressure level, thereby forming a highly crystalline blend;

f) irradiating the blend at a temperature below the melt with ionizing radiation, thereby forming a highly crystalline cross-linked blend;

g) pressuring the highly crystalline, highly cross-linked blend under at least 10-1000 MPa;

h) heating the pressurized cross-linked blend under at least about 10-1000 MPa;

i) heating the pressurized cross-linked blend to a temperature of above 100°C to below the melt of the pressurized highly crystalline, highly cross-linked blend;

j) holding at this pressure and temperature;

k) cooling the heated cross-linked blend to about room temperature; and

l) releasing the pressure to about an atmospheric pressure level, thereby forming oxidation-resistant highly crystalline highly cross-linked blend of polymeric material and additive.

50. A method of making oxidation-resistant cross-linked highly crystalline blend of polymeric material and additive comprising:

a) blending the polymeric material with an additive;

b) consolidating the blend;

c) heating the blend to a temperature above the melt;

d) pressurizing the blend under at least 10-1000 MPa;

e) holding at this pressure and temperature;

f) cooling the heated blend to about room temperature;

g) releasing the pressure to about an atmospheric pressure level, thereby forming a highly crystalline blend;

h) irradiating the blend at a temperature below the melt with ionizing radiation, thereby forming a highly crystalline cross-linked blend;

i) mechanically deforming the highly crystalline highly cross-linked blend below its melting point; and

j) annealing the mechanically deformed highly crystalline highly crosslinked blend at a temperature below the melting point, thereby forming oxidation-resistant highly crystalline highly cross-linked blend of polymeric material and additive.

51. A method of making oxidation-resistant cross-linked highly crystalline blend of polymeric material and additive comprising:

a) blending the polymeric material with an additive;

b) consolidating the blend;

c) pressuring the blend under at least 10-1000 MPa;

d) heating the pressurized blend to a temperature of above 100°C to below the melt of the pressurized blend;

e) holding at this pressure and temperature;

f) cooling the heated blend to about room temperature;

g) releasing the pressure to about an atmospheric pressure level, thereby forming a highly crystalline blend;

h) irradiating the blend at a temperature below the melt with ionizing radiation, thereby forming a highly crystalline cross-linked blend;

i) mechanically deforming the highly crystalline highly cross-linked blend below its melting point; and

j) annealing the mechanically deformed highly crystalline highly crosslinked blend at a temperature below the melting point, thereby forming oxidation-resistant highly crystalline highly cross-linked blend of polymeric material and additive.

52. A method of making oxidation-resistant highly cross-linked blend of polymeric material and additive comprising:

a) blending the polymeric material with an additive;

b) consolidating the blend;

c) irradiating the blend at a temperature below the melt with ionizing radiation, thereby forming a cross-linked blend;

d) mechanically deforming highly cross-linked blend below its melting point; and

e) annealing the mechanically deformed highly crosslinked blend at a temperature below the melting point, thereby forming oxidation-resistant highly cross-linked blend of polymeric material and additive.

53. A method of making oxidation-resistant highly cross-linked blend of polymeric material and additive comprising:

a) blending the polymeric material with an additive;

b) consolidating the blend;

c) irradiating the blend at a temperature below the melt with ionizing radiation, thereby forming a cross-linked blend;

d) mechanically deforming highly cross-linked blend below its melting point;

e) annealing the mechanically deformed highly crosslinked blend at a temperature below the melting point, thereby forming oxidation-resistant highly cross-linked blend;

f) pressurizing the oxidation-resistant, highly cross-linked blend to at least 10-1000 MPa;

g) heating the pressurized highly cross-linked blend to a temperature of above 100°C to below the melt of the pressurized highly cross-linked blend;

h) holding at this pressure and temperature;

i) cooling the heated highly cross-linked blend to about room temperature; and

j) releasing the pressure to about an atmospheric pressure level, thereby forming oxidation-resistant highly crystalline highly cross-linked blend of polymeric material and additive.

54. The method according to any of claims 1, 2, 9, 10, 15, 16, 19, 20, and 40-53, wherein the pressure is at least about 150 MPa, 250 MPa, 310MPa, 400MPa, or 450MPa.

55. The method according to any of claims 40-54, wherein the irradiation dose is more than 1 kGy to 1000 kGy, or more.

56. The method according to any of claims 40-54, wherein the irradiation dose is about 25-400 kGy or more.

57. The method according to any of claims 40-54, wherein the irradiation dose is at least about 150 kGy.